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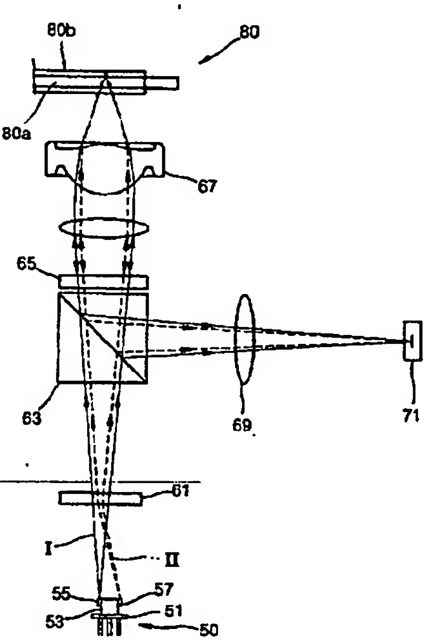
(54) Compatible optical pickup

(57) An optical pickup compatible for recording media having different formats, in which two light beam sources for different wavelengths of light are installed in a single light device module. The optical pickup includes: a light device module (50) having a first light beam source (55) and a second light beam source (57) for emitting first and second light beams, respectively, having different wavelengths; a hologram light coupler (61) for separately guiding the first and second light beams along the same optical path such that the first and second light beams go toward a corresponding recording medium (80) ; an optical path changing element for altering the optical path of an incident light beam; and an objective lens (67) disposed on an optical path between the optical path changing element the corresponding recording medium (80), for focusing the first or second light beam on the corresponding recording medium (80); and a photodetector (71) for receiving the first or second light beam incident from the optical path changing element after having been reflected from the corresponding recording medium (80), and detecting an information signal and error signals from the received light beam.

FIG. 2



EP 1 174 865 A2

Description

[0001] The present invention relates to an optical pickups compatible for recording media having different formats, and more particularly, to a compact optical pickup compatible for recording media with different formats, which adopts a single light device module in which two light beam sources for different wavelengths of light are installed.

[0002] In recent years, the need for an optical pickup capable of recording information on and/or reproducing information from a digital versatile disc-read only memory (DVD-ROM) at high densities be compatible with compact disc (CD) family media such as CD, recordable CD (CD-R), CD rewritable (CD-RW), CD interactive (CD-I) and CD plus graphics (CD+G) has arisen.

[0003] The standard thickness of existing CD family media is 1.2 mm, whereas the thickness of DVDs has been standardized to 0.6 mm in consideration of the allowable error in the tilt angle of a disc and the numerical aperture (NA) of an objective lens. Accordingly, when recording information on or reproducing information from a CD using an optical pickup designed for DVDs, spherical aberrations occur due to a difference in the thicknesses therebetween. Such spherical aberration cannot provide a light intensity sufficient for recording an information (radio frequency) signal or may deteriorate a reproduction signal from the CD. Also, DVDs and CD family media utilize different wavelengths of light for reproduction: CDs use light having a wavelength of about 780nm as a light beam source, whereas DVDs use light having a wavelength of about 650nm as a light beam source. Thus, for the compatibility with CDs, an optical pickup adopting a light beam source capable of emitting different wavelengths of light, and capable of focusing optical spots at different focal positions is required.

[0004] Referring to Figure 1, a conventional compatible optical pickup comprises a first light beam source 21 for emitting light having a wavelength of about 650nm, and a second light beam source 31 for emitting light having a wavelength of about 780nm. The first light beam source 21 is appropriate for a relatively thin disc 10a, such as a DVD, and the second light beam source 31 is appropriate for a relatively thick disc 10b, such as a CD.

[0005] Light emitted from the first light beam source 21 is condensed by a first collimator lens 23, parallel incident on a first polarization beam splitter (PBS) 25, and then reflected by the first PBS 25 toward the DVD 10a. After reflected by the relatively thin disc 10a, the reflected light is transmitted through the first PBS 25 and is then received by a first photodetector 27. Here, an interference filter 41 for changing the paths of light emitted from the first and second light beam sources 21 and 31, a quarter-wave plate 43, a variable diaphragm 45, and an objective lens 47 for condensing light incident are disposed on an optical path between the first PBS 25 and the disc 10.

[0006] Light emitted from the second light beam source 31 is condensed by a second collimator lens 33, parallel incident on a second PBS 35, transmitted through a condenser lens 37, and then incident on the interference filter 41. The light is reflected by the interference filter 41 and passes through the quarter-wave plate 43, the variable diaphragm 45 and the objective lens 47 in sequence to form an optical spot on the relatively thick disc 10b.

[0007] Light reflected by the relatively thick disc 10b is incident on the interference filter 41 through the objective lens 47, the variable diaphragm 45 and the quarter-wave plate 43, and then reflected by the interference filter 41 heading toward the second PBS 35. The light is reflected by the second PBS 35 and received by a second photodetector 39.

[0008] The interference filter 41, an optical element for transmitting or reflecting incident light depending on the wavelength of incident light, transmits the light originating from the first light beam source 21, and reflects the light originating from the second light beam source 31. The variable diaphragm 45 has a variable aperture, and defines the size of the light spot incident on the objective lens 47, such that the light beam enters the region of the objective lens 47 with an NA less than 0.45 or 0.47. The quarter-wave plate 43 is an optical element for changing the polarization of incident light. As each of the light beams from the first and second light beam sources 21 and 31 passes the quarter-wave plate 43 two times, the polarization of the incident beams changes, and then the light beams head toward the first PBS 25 and the second PBS 353, respectively. The objective lens 47 allows light from the first and second light beam sources 21 and 31 to be focused as a light spot on the recording surface of each of the DVD 10a and the CD 10b.

[0009] Although the convention optical pickup having the configuration described above is convertible with CD-R using two light beam sources, the adoption of the variable diaphragm, which is manufactured through sophisticated and expensive processes, makes assembling of such optical pickup complicate and increases the manufacturing cost. In addition, the first and second light beam sources are separately constructed, so that the configuration of the optical pickup becomes complicated and the optical arrangement thereof is also difficult.

[0010] It is an aim of embodiments of the present invention to provide a compact optical pickup compatible for recording media having different formats, in which first and second light beam sources for different wavelengths of light are installed in a single light device module, and the optical paths of light beams from the first and second light beam sources are adjusted using a hologram light coupler.

[0011] According to a first aspect of the present there is provided an optical pickup compatible for recording

media having different formats, the optical pickup comprising: a light device module having a first light beam source and a second light beam source for emitting first and second light beams, respectively, having different wavelengths; a hologram light coupler for separately guiding the first and second light beams along the same optical path such that the first and second light beams go toward a corresponding recording medium; an optical path changing unit for altering the optical path of an incident light beam; and an objective lens disposed on an optical path between the optical path changing unit the corresponding recording medium, for focusing the first or second light beam on the corresponding recording medium; and a photodetector for receiving the first or second light beam incident from the optical path changing unit after having been reflected from the corresponding recording medium, and detecting an information signal and error signals from the received light beam.

[0012] Preferably, the hologram light coupler includes a hologram pattern which allows the first light beam entering in perpendicular to one surface of the hologram light coupler to directly transmit, and almost all the second light beam entering at an angle to diffract and transmit, such that the second light beam travels parallel to the first light beam.

[0013] Preferably, the first light beam has a wavelength of about 650 nm and the second light beam has a wavelength of about 780 nm, and a maximum pattern depth D_p of the hologram pattern satisfies the expression: 4,000 nm $\leq D_p \leq$ 7,000 nm.

[0014] Preferably, the hologram pattern has a stepped configuration with at least two steps.

[0015] Preferably, a positional tolerance between the first and second light beam sources is controlled by adjusting the location of the hologram light coupler on the optical path between the light device module and the objective lens.

[0016] According to a second aspect of the present invention there is provided the optical pickup, the optical path changing unit includes: a polarization beam splitter for altering the traveling path of an incident light beam by transmitting or reflecting the incident light beam according to the polarization of the incident light beam; and a quarter-wave plate disposed on the optical path between the polarization beam splitter and the objective lens, for changing the polarization of an incident light beam.

[0017] Preferably, the objective lens has a light receiving surface for receiving the first or second light beam emitted from the light device module, and a light emitting surface facing the corresponding recording medium, and at least one of the light receiving and transmitting surfaces of the objective lens is divided into sections by at least one an annular region, the sections being concentric with each other and having different aspheric curvatures.

[0018] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a schematic view showing the optical arrangement of a conventional compatible optical pickup;

Figure 2 is a schematic view showing the optical arrangement of an optical pickup compatible for recording media having different formats according to embodiments of the present invention;

Figure 3 is a sectional view showing the pattern of a first embodiment of a hologram light coupler adopting in the optical pickup according to the present invention;

Figure 4 is a graph showing variations of transmittance with respect to the pattern depth of the hologram light coupler of Figure 3;

Figure 5 illustrates the diffraction efficiency of the hologram light coupler of Figure 3;

Figure 6 is a sectional view showing the pattern of a second embodiment of the hologram light coupler adopted in the optical pickup according to present invention;

Figure 7 is a graph showing variations of transmittance with respect to the pattern depth of the hologram light coupler of Figure 6;

Figure 8 is a sectional view showing the pattern of a third embodiment of the hologram light coupler adopted in the optical pickup according to the present invention;

Figure 9 is a graph showing variations of transmittance with respect to the pattern depth of the hologram light coupler of Figure 8;

Figure 10 is a sectional view showing the pattern of a fourth embodiment of the hologram light coupler adopted in the optical pickup according to the present invention;

Figure 11 is a graph showing variations of transmittance with respect to the pattern depth of the hologram light coupler of Figure 10;

Figure 12 is a schematic front view of an objective lens adopted in the compatible optical pickup according to embodiments of the present invention; and

Figure 13 is a schematic view showing the major parts of the compatible optical pickup according to embodiments of the present invention.

[0019] Referring to Figure 2, a preferred embodiment of an optical pickup compatible for recording media having different formats includes a light device module 50, which includes first and second light beam sources 55 and 57 for emitting a first light beam I and a second light beam II having different wavelengths, respectively, a hologram light coupler 61 by which the first and second light beams I and II from the light device module 50 are guided to travel along the same optical path, an optical path changing unit for altering the traveling path of incident light, an objective lens 67 for focusing incident light on an optical recording medium 80, and a photodetector 71 for receiving light passed through the objective lens 67 and the optical path changing unit after having been reflected from the recording medium 80.

[0020] In particular, the light device module 50 includes a substrate 51, a mount 53 on the substrate 51, and the first and second light beam sources 55 and 57 attached to both sides of the mount 53, respectively. The first and second light beam sources 55 and 57 as edge emitting lasers emit light beams at different diverging angles The first light beam I from the first light beam source 55 has a wavelength of about 650 nm, and is appropriate for the relatively thin optical disc 80a such as a DVD. The second light beam II from the second light beam source 57 has a wavelength of about 780 nm, and is appropriate for the relatively thick optical disc 80b such as CDs. The positional tolerance between the first and second light beam sources 55 and 57 can be controlled by adjusting the location of the hologram light coupler 61 on the optical path between the light device module 50 and the objective lens 67.

[0021] The hologram light coupler 61 guides the first and second light beams I and II along the same optical path and directs the first and second light beams I and II toward the optical recording medium 80. The hologram light coupler 61 has a hologram pattern 61a at one surface thereof to diffract and transmit incident light. The hologram light coupler 61 directly transmits the first light beam I entering in perpendicular to the light receiving surface of the hologram light coupler, and diffracts and transmits most of the second light beam II incident at an angle, such that the second light beam II becomes parallel to the first light beam I. Transmittance of the hologram light coupler 61 is determined by the depth of the hologram pattern 61a, the pitch of the hologram pattern 61, and the configuration of the hologram pattern 61. It is preferable that the hologram pattern 61a of the hologram light coupler 61 has a stepped pattern including at least two steps.

[0022] Figure 3 illustrates an example of the hologram pattern with five steps, and Figure 4 illustrates variations of transmittance of the first and second light beams I and II with respect to the variations of maximum pattern depth D_p of the hologram pattern of Figure 3. Referring to Figure 4, at a maximum pattern depth D_p of about 6,400 nm, the transmittance of the hologram light coupler 61 is about 1.0 for the principle zeroth order maximum of the first light beam I having a 650nm wavelength. The second light beam II is diffracted and transmitted into zeroth order and ±1st order diffracted beams. The transmittance of the hologram light coupler 61 is about 8% for the zeroth order diffracted beam, almost 0% for the +1st order diffracted beam, and about 75% for the -1st order diffracted beam with respect to the amount of the incident light. The -1st order diffracted beam serves as the effective beam for the second light beam II, and travels parallel to the zeroth order diffracted beam from the first light beam I.

[0023] As previously mentioned, the hologram light coupler 61 is appropriately located on the optical path such that the first and second light beams I and II from the first and second light beam sources 55 and 57 installed in the light device module 80, but at different angles with respect to the optical axis, are guided along the same optical path and go toward the optical recording medium 80.

[0024] Although the hologram light coupler 61 of Figure 3 is designed to have the 5-step hologram pattern, the hologram pattern of the hologram light coupler 61 can be varied as shown in Figures 6, 8 and 10. Figure 6 illustrates a 4-step hologram pattern for the hologram light coupler 61, and Figure 7 illustrates variations of transmittance for the first and second light beams I and II with respect to the maximum pattern depth D_p. In designing the hologram pattern shown in Figure 6, the phase of light beam is also considered. For the 4-step hologram pattern of Figure 6, the pitch TP1 at the maximum pattern depth D_p is larger than the pitches TP2, TP3 and TP4 for the other steps.

[0025] Referring to Figure 7. at a maximum pattern depth D_p of about 4,900 nm, the transmittance of the hologram light coupler 61 is about 1.0 for the zeroth order maximum of the first light beam I having a 650nm wavelength. The second light beam II is diffracted and transmitted into zeroth order and ±1st order diffracted beams. The transmittance of the hologram light coupler 61 is about 10% for the zeroth order diffracted beam, almost 0% for the +1st order diffracted beam, and about 65% for the -1st order diffracted beam with respect to the amount of the incident light. The -1st order diffracted beam serves as the effective beam for the second light beam II, and travels parallel to the zeroth order diffracted beam from the first light beam I.

[0026] Figure 8 illustrates another 4-step hologram pattern for the hologram light coupler 61, in which no phase of light beam is considered, and Figure 9 illustrates variations of transmittance for the first and second light beams I and II with respect to the maximum pattern depth D_p. For the 4-step hologram pattern of Figure 8, the pitch TP1 at the maximum pattern depth D_p is equal to the pitches TP2, TP3 and TP4 for each of the other

steps.

[0027] Referring to Figure 9, at maximum pattern depth D_p of about 4,900 nm, the transmittance of the hologram light coupler 61 is about 1.0 for the zeroth order maximum of the first light beam I having a 650nm wavelength. The transmittance of the hologram light coupler 61 is almost 0% for both the zeroth order diffracted beam and +1st order diffracted beam from the second light beam II, and about 86% for the -1st order diffracted beam with respect to the amount of the incident light. The -1st order diffracted beam serves as the effective beam for the second light beam II, and travels parallel to the zeroth order diffracted beam from the first light beam I.

[0028] Figure 10 illustrates a 2-step hologram pattern for the hologram light coupler 61, in which no phase of light beam is considered, and Figure 11 illustrates variations of transmittance for the first and second light beams I and II with respect to the maximum pattern depth D_p. For the 2-step hologram pattern of Figure 10, the pitch TP1 at the maximum pattern depth D_p is equal to the pitch TP2 of the other step of the hologram pattern.

[0029] Referring to Figure 11, at a maximum pattern depth D_p of about 4,900 nm, the transmittance of the hologram light coupler 61 is about 1.0 for the zeroth order maximum of the first light beam I of wavelength 650nm. The transmittance of the hologram light coupler 61 is almost 0% for both the zeroth order diffracted beam and +1st order diffracted beam from the second light beam II, and about 68% for the -1st order diffracted beam with respect to the amount of the incident light. The -1st order diffracted beam serves as the effective beam for the second light beam II, and travels parallel to the zeroth order diffracted beam from the first light beam I.

[0030] As can be inferred from the examples of the hologram pattern for the hologram light coupler 61 illustrated above, the maximum pattern depth D_p of the hologram light coupler 61 can be varied according to the stepped configuration. It is preferable that the maximum hologram depth D_p of the hologram light coupler satisfies the expression: 4,000 nm $\leq D_p \leq$ 7,000 nm.

[0031] As previously mentioned, the zeroth order diffracted beam is utilized as the effective beam for the first light beam I, and the -1st order diffracted beam is utilized as the effective beam for the second light beam II. For this reason, the first and second light beams I and II emerging from the different light beam sources separated from each other can travel on the same path. The first and second light beams I and II passed through the hologram light coupler 61 diverges at different angles, so that the first light beam I is focused on the relatively thin optical disc 80a and the second light beam II is focused on the relatively thick optical disc 80b.

[0032] Turning to Figure 2, the optical path changing unit includes a polarization beam splitter (PBS) 63 for altering the traveling path of incident light beams by transmitting or reflecting incident light beams according to their polarization, and a quarter-wave plate 65, which is disposed on the optical path between the PBS 63 and the objective lens 67, for changing the polarization of incident light beams. The light beams emitted from the light device module 50 pass through the PBS 63 and go toward the optical recording medium 80.

[0033] As a light beam heading toward the optical recording medium 80, and the light beam reflected from the optical recording medium 80 pass through the quarter-wave plate 65, the polarization of incident light beam changes. After the light beam reflected by the optical recording medium 80 is incident on the PBS 63, the incident light beam is reflected by the PBS 63 such that it goes toward the photodetector 71.

[0034] The objective lens 67 focuses the incident first or second light beams I and II on the relatively thick disc 80a or the relatively thin disc 80b, respectively. To achieve this, the objective lens 67 has a light receiving surface for receiving light emitted from the light device module 50, and a light emitting surface which faces the optical recording medium 80. It is preferable that at least one of the light receiving and transmitting surfaces is divided into concentric sections by at least one annular region. Here, each of the sections has a different aspheric curvature such that light beams passed through the sections can be focused at different positions.

[0035] In particular, referring to Figures 12 and 13, the objective lens 67 includes a near-axis region 67a, an annular lens region 67b and a far-axis region 67c. The annular lens region 73 located between the near-axis region 67a and the far-axis region 67c may be formed as a circular or elliptical ring. The annular lens region 67b has an aspherical surface. It is preferable that the annular lens region 67b is optimized for the relatively thick optical disc 80b.

[0036] When the relatively thin optical disc 80a is employed as the optical recording medium 80, light is emitted from the first light beam source 55 and then focused as a light spot on the information recording surface of the relatively thin optical disc 80a through the far-axis region 67a. In contrast, light emerging from the annular lens region 67b is scattered.

[0037] On the other hand, when the relatively thick optical disc 80a is employed as the optical recording medium 80, light is emitted from the second light beam source 55, and then focused as a light spot on the information recording surface of the relatively thick optical disc 80c through both the annular lens 67b and the near-axis region 67a.

[0038] The optical pickup may further include a collimating lens 66 on the optical path between the objective lens 67 and the quarter-wave plate 65, for condensing incident light. The photodetector 71 receives the first light beam I or second light beam II light incident from the optical path changing unit after having been reflected from the optical recording medium 80, and detects an information signal and error signals from the incident

light. A sensor lens 69 for causing astigmatism to light may further disposed on the optical path between the PBS 63 and the photodetector 71.

[0039] As previously mentioned, the optical pickup according to the present invention, which is compatible for recording media having different formats, adopts a single light device module in which first and second light beam sources for different wavelengths of light are installed, and uses a hologram light coupler such that light beams from the first and second light beam sources, which are separated from each other, are guided along the same optical path. In addition, the optical pickup according to the present invention detects an information signal and error signals with a single photodetector. Thus, the configuration of the optical pickup becomes compact.

[0040] While this invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

[0041] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0042] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0043] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0044] The invention is not restricted to the details of the foregoing embodiment(s). The invention extend to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An optical pickup compatible for recording media having different formats, the optical pickup comprising:

   a light device module (50) having a first light beam source (55) and a second light beam source (57) for emitting first and second light beams, respectively, having different wavelengths;

   a hologram light coupler (61) for separately guiding the first and second light beams along the same optical path such that the first and second light beams go toward a corresponding recording medium (80);

   an optical path changing unit for altering the optical path of an incident light beam; and

   an objective lens (67) disposed on an optical path between the optical path changing unit the corresponding recording medium (80), for focusing the first or second light beam on the corresponding recording medium (80); and

   a photodetector (71) for receiving the first or second light beam incident from the optical path changing unit after having been reflected from the corresponding recording medium (80), and detecting an information signal and error signals from the received light beam.

2. The optical pickup of claim 1, wherein the hologram light coupler includes a hologram pattern (61a) which allows the first light beam entering in perpendicular to one surface of the hologram light coupler to directly transmit, and almost all the second light beam entering at an angle to diffract and transmit, such that the second light beam travels parallel to the first light beam.

3. The optical pickup of claim 2, wherein the first light beam has a wavelength of about 650 nm and the second light beam has a wavelength of about 780 nm, and a maximum pattern depth D_p of the hologram pattern satisfies the expression: $4{,}000 \text{ nm} \leq D_p \leq 7{,}000 \text{ nm}$.

4. The optical pickup of claim 3, wherein the hologram pattern has a stepped configuration with at least two steps.

5. The optical pickup of claim 1, wherein a positional tolerance between the first and second light beam sources is controlled by adjusting the location of the hologram light coupler (61) on the optical path between the light device module (50) and the objective lens (67).

6. The optical pickup of any of claims 1 through 5, wherein the optical path changing unit includes:

   a polarization beam splitter (63) for altering the

traveling path of an incident light beam by transmitting or reflecting the incident light beam according to the polarization of the incident light beam; and

a quarter-wave plate (65) disposed on the optical path between the polarization beam splitter (63) and the objective lens (67), for changing the polarization of an incident light beam.

7. The optical pickup of any of claims 1 through 6, wherein the objective lens (67) has a light receiving surface for receiving the first or second light beam emitted from the light device module, and a light emitting surface facing the corresponding recording medium, and at least one of the light receiving and transmitting surfaces of the objective lens is divided into sections by at least one an annular region (67b), the sections being concentric with each other and having different aspheric curvatures.

FIG. 1 (PRIOR ART)

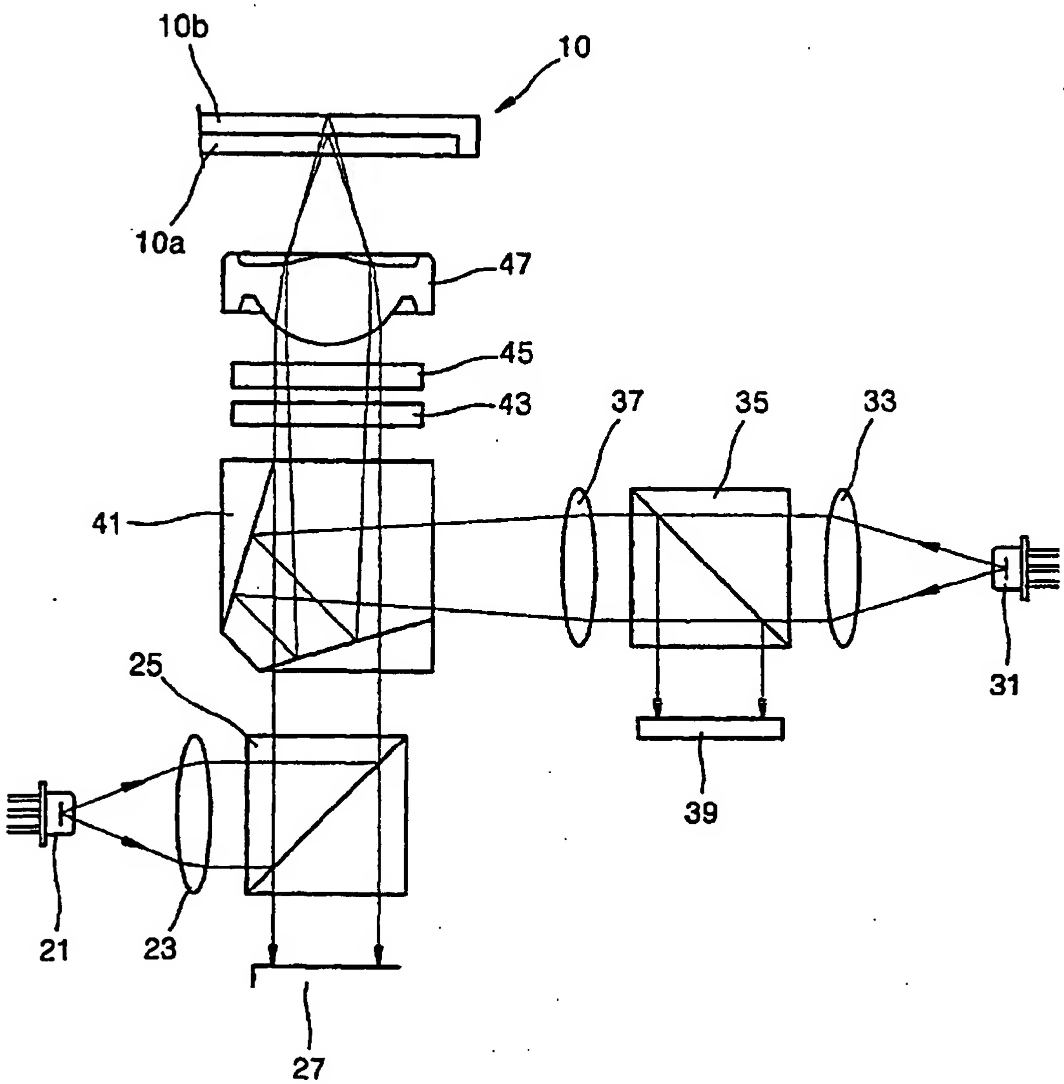


FIG. 2

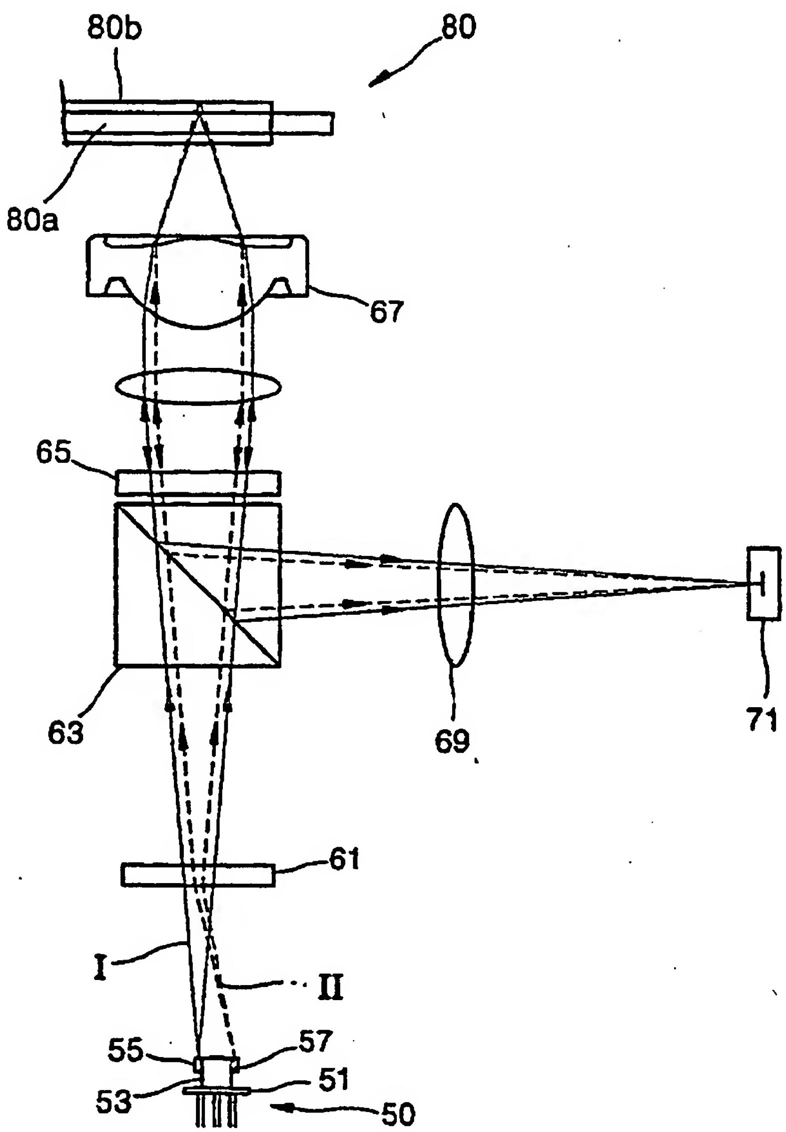


FIG. 3

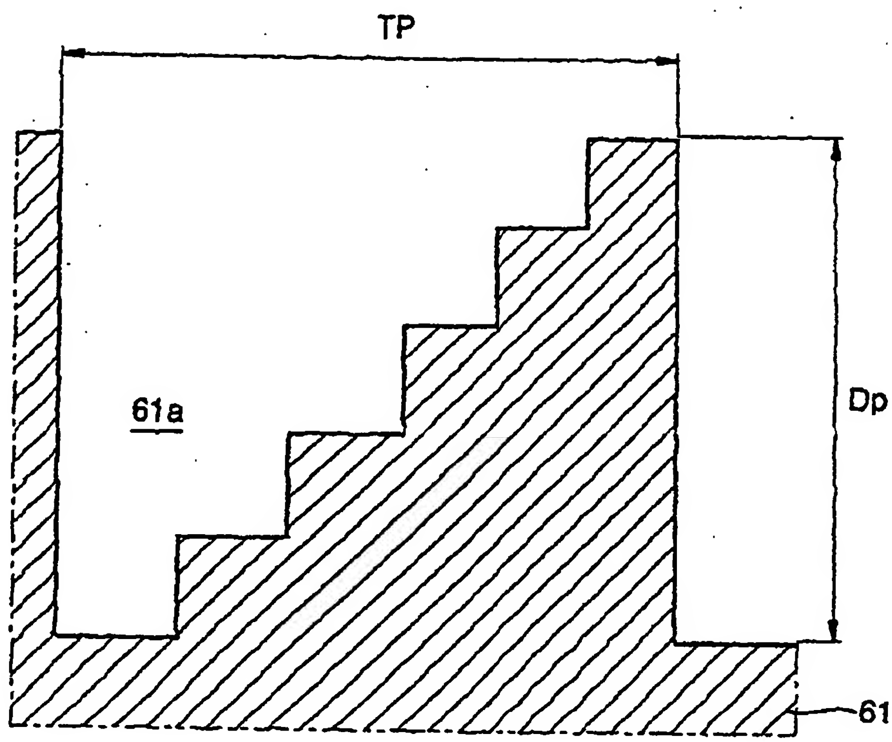
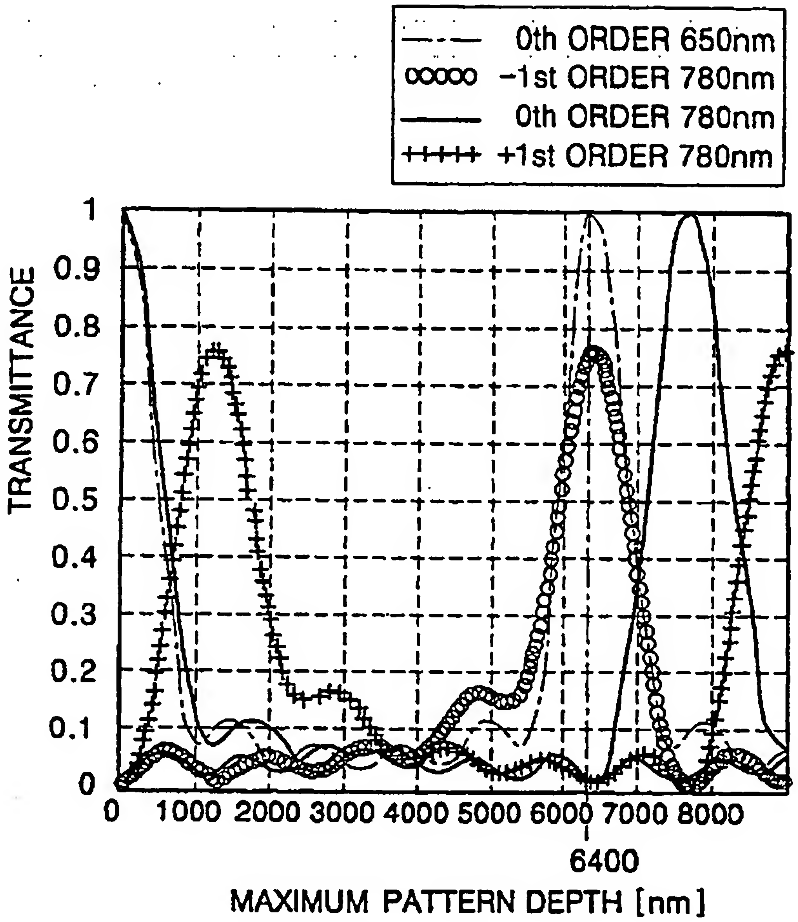


FIG. 4


0th ORDER 650nm
-1st ORDER 780nm
0th ORDER 780nm
+1st ORDER 780nm
TRANSMITTANCE
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
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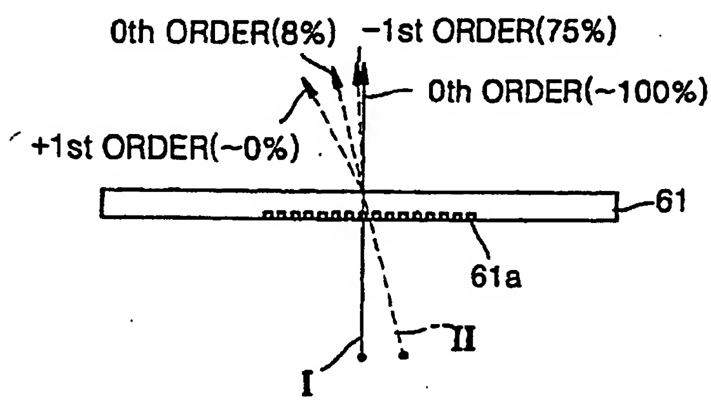
1000
2000
3000
4000
5000
6000
7000
8000
6400
MAXIMUM PATTERN DEPTH [nm]

FIG. 5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-1st ORDER(75%)
0th ORDER(~100%)
+1st ORDER(~0%)
61
61a
II
I

FIG. 6

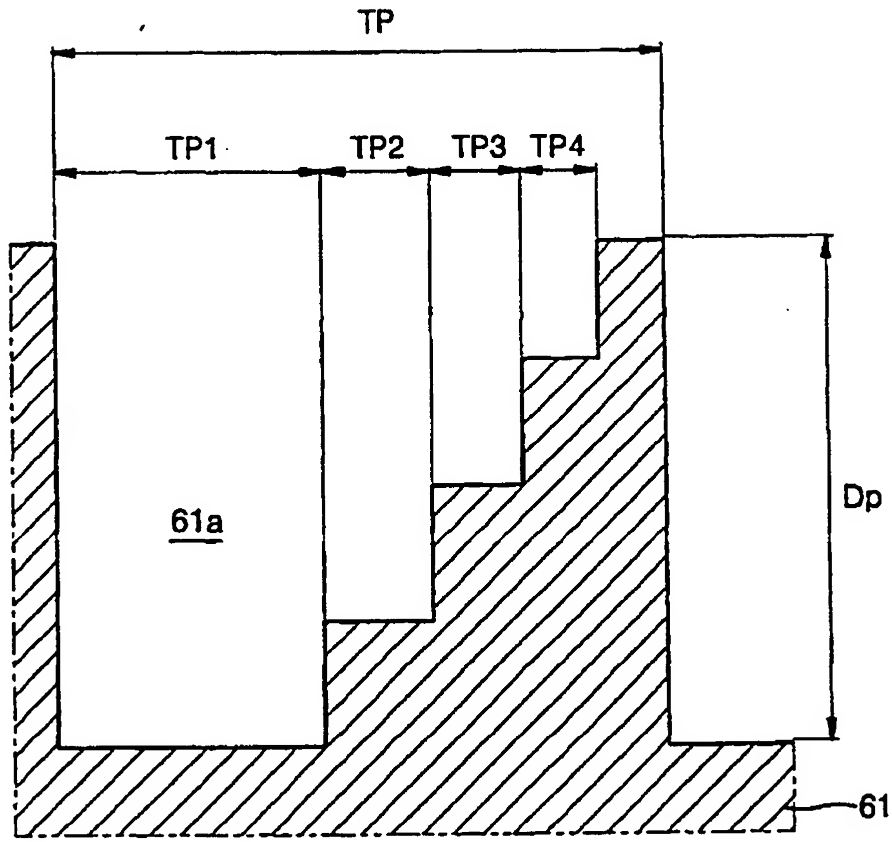
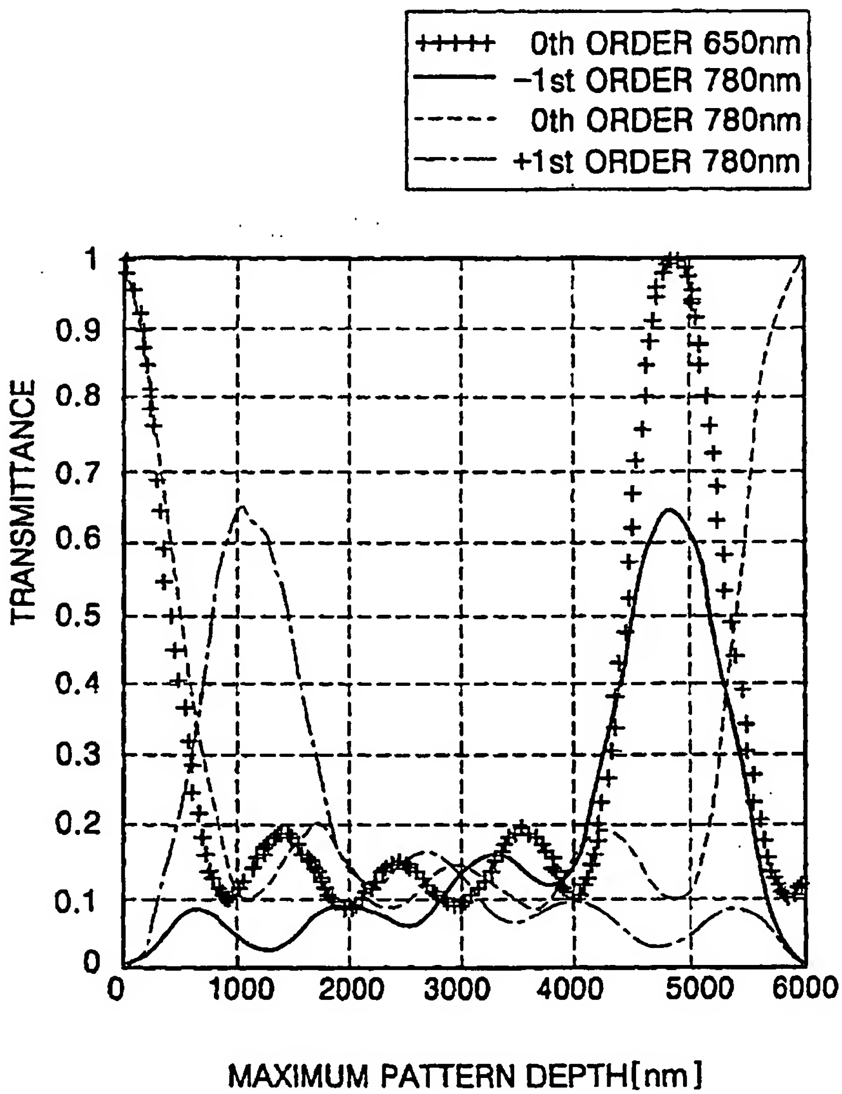


FIG. 7



+++++ 0th ORDER 650nm
–1st ORDER 780nm
0th ORDER 780nm
+1st ORDER 780nm
TRANSMITTANCE
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0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
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3000
4000
5000
6000
MAXIMUM PATTERN DEPTH[nm]

FIG. 8

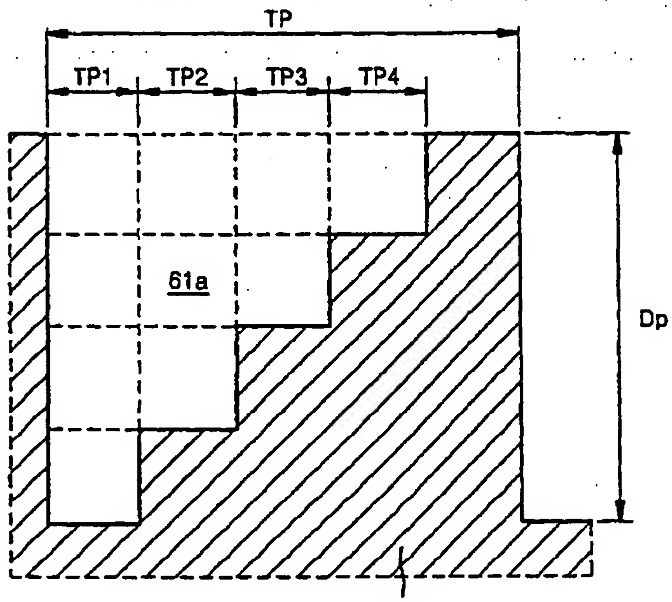
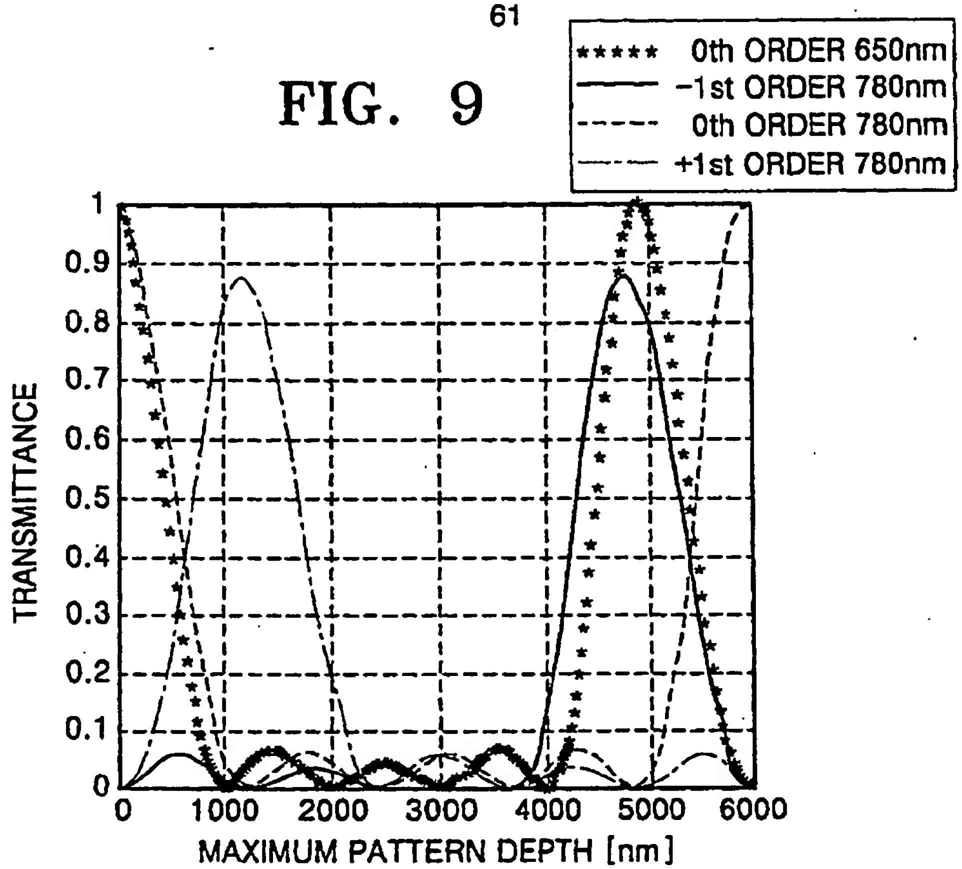

TP
TP1
TP2
TP3
TP4
61a
Dp
61

FIG. 9


0th ORDER 650nm
−1st ORDER 780nm
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+1st ORDER 780nm
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0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1000
2000
3000
4000
5000
6000

FIG. 10

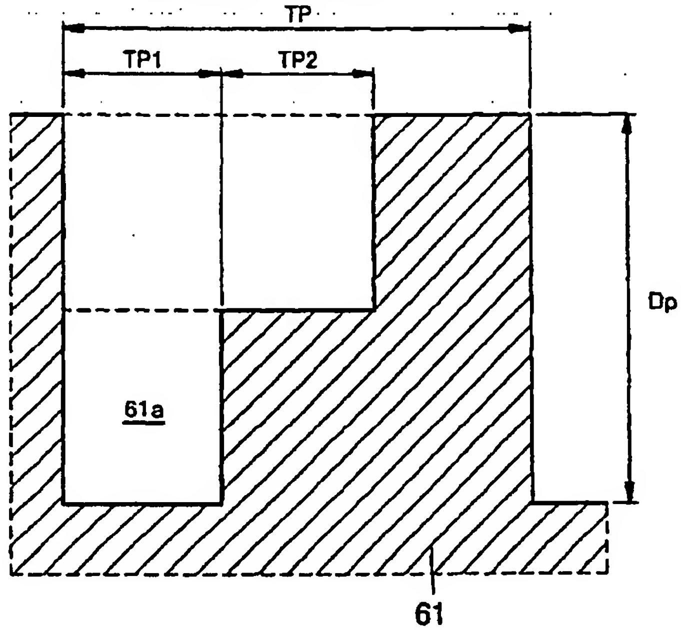
TP
TP1
TP2
Dp
61a
61

FIG. 11

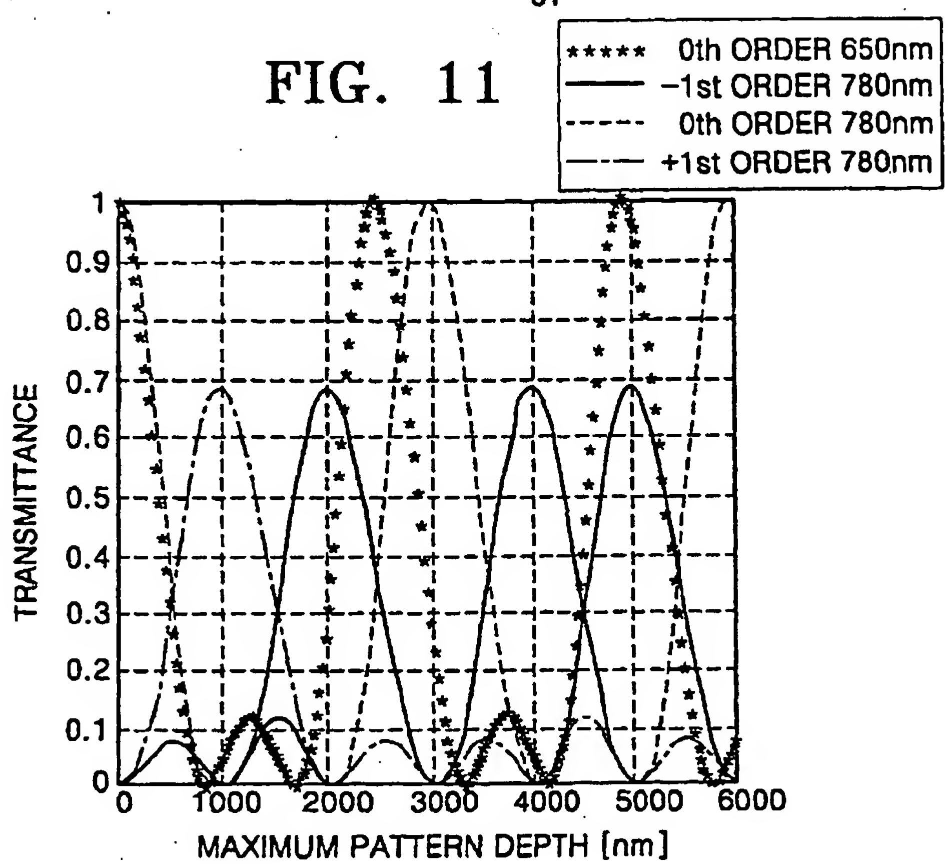
***** 0th ORDER 650nm
−1st ORDER 780nm
0th ORDER 780nm
+1st ORDER 780nm
TRANSMITTANCE
MAXIMUM PATTERN DEPTH [nm]
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1000
2000
3000
4000
5000
6000

FIG. 12

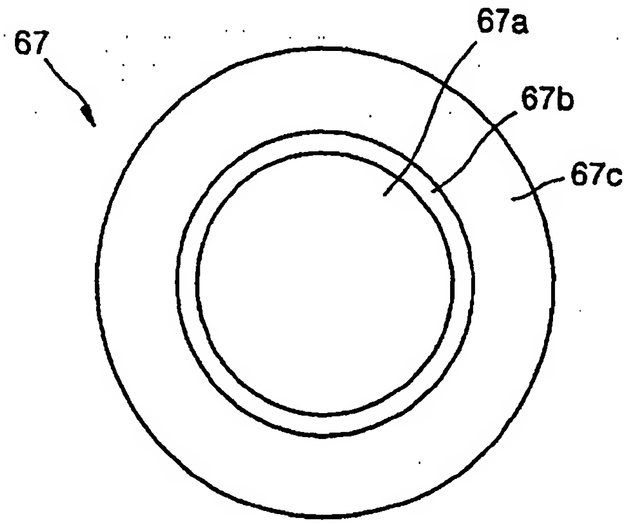

FIG. 13